# Space Weather Technical Forecast

Issued on Monday, 09 January 2023 at 12:36 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

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**Space Weather Forecast Headline: M-class flares likely, chance of X-class flares throughout. Chance of Active fluence by Day 4 (12 Jan).**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity has been Moderate with four M-class flares observed in the past 24 hours, most originating from AR3184, which is emerging around the southeast limb. This region is currently difficult to classify as it is not yet fully visible, but is likely to be more complex than we can see at present. However, the largest flare was an M2 flare peaking at 09/0901 UTC from AR3181. This region is in a good position to produce an Earth-directed CME, but we don't currently have enough imagery to confirm whether this flare gave a CME. AR3182 and AR3181 are the two largest and most complex regions on the visible disc, with both showing small delta spots. A new region in the north is still growing, but other regions have remained stable. Apart from the aforementioned flare, no Earth-directed CMEs have been observed in the past 24 hours.

**Solar Wind / Geomagnetic Activity:** Solar winds, as observed by DSCOVR at L1, have declined to ambient levels through the period. Wind speeds were initially slightly elevated around 430 km/s, declining to near 370 km/s. Density was average or below average. Total IMF, Bt, was weak at 6 nT or below. The north-south component, Bz, varied weakly between +/-5 nT. Phi angle was predominately negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 0-3) throughout.

**Energetic Particles / Solar Radiation:** The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2 MeV) has been at mostly background levels. The 24-hour integrated electron fluence rose a little, but stayed well below the Active threshold, reaching 4.32e6 integrated pfu at 09/0001 UTC.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity is likely to be Low to Moderate, with a chance of X-class flares through the forecast period, these most likely from AR3182, AR3181 or AR3184 which is currently emerging around the southeast limb.

**Solar Wind / Geomagnetic Activity:** No Earth directed CMEs are currently expected. Solar wind speeds are now at ambient levels, and are expected to remain ambient through the rest of Day 1 (09 Jan). The next feature of interest is CH62/-, with the HSS likely to arrive on Day 2 (10 Jan). Geomagnetic activity is expected to be mostly Quiet at first, increasing with the HSS arrival on Day 2 to become Unsettled to Active, with a slight chance of a G1/Minor Storm. Activity then slowly declining through Days 3 and 4 (11-12 Jan).

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux observed by GOES-16 is likely to remain at background levels throughout. However, there is a risk of an increase should any significant flares occur, giving a slight chance of exceeding the S1/Minor Storm threshold. Electron fluence is likely to remain below the Active (1e8 integrated pfu) threshold, but a rise is possible towards the end of the period.

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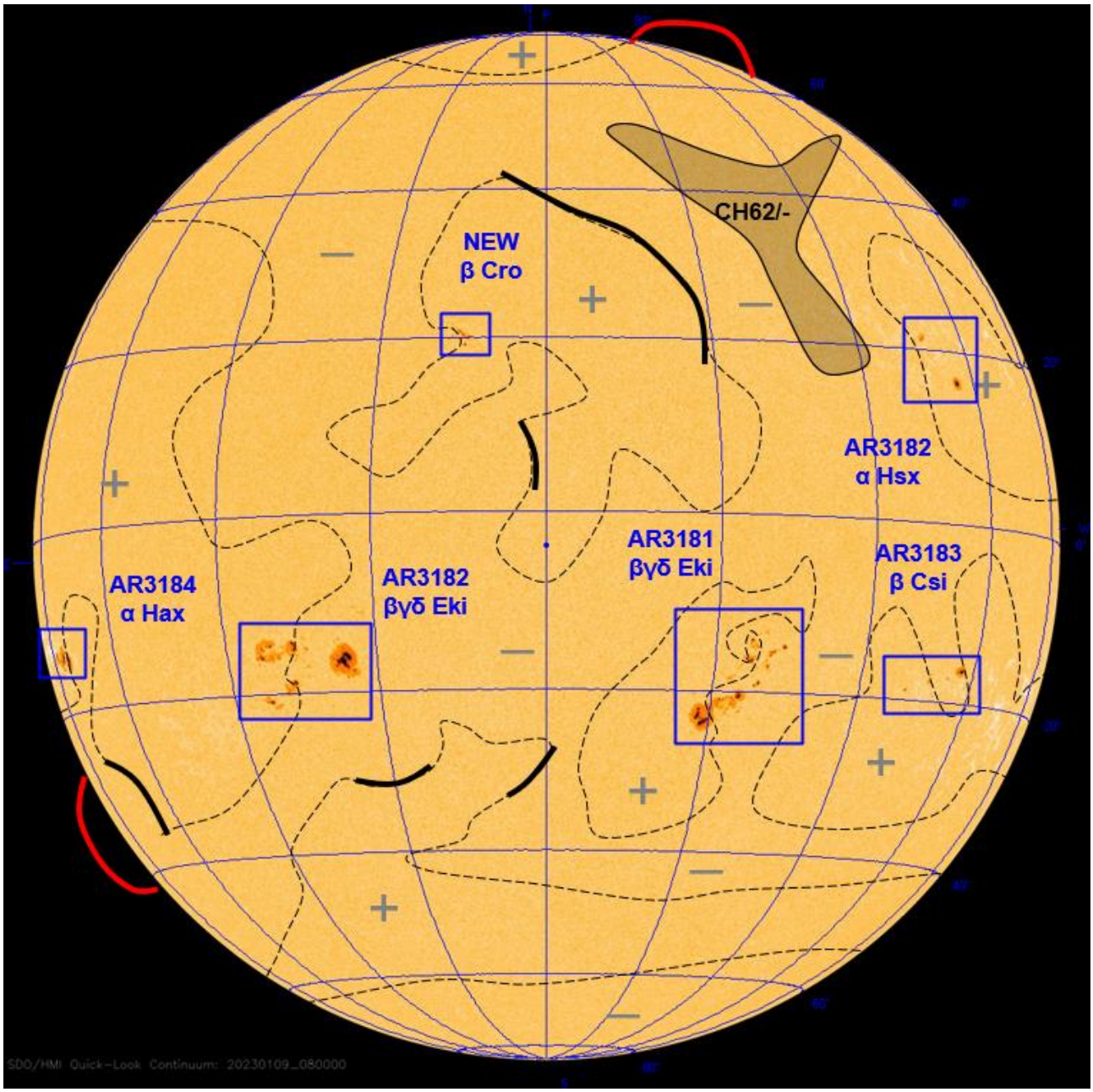
**Figure 1. Solar Analysis Valid 09/0800 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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# Met Office Space Weather Technical Forecast

## Geomagnetic Storms:

No Earth directed CMEs are currently expected.

Solar wind speeds are now at ambient levels after a weak High Speed Stream (HSS), and are expected to remain ambient through the rest of Day 1 (09 Jan). The next feature of interest is CH62/-, with the HSS likely to arrive on Day 2 (10 Jan). This feature was faintly visible on the previous rotation but didn't produce a HSS. It is much more clearly visible this time around, suggesting it is more intense and therefore more likely to give an increase in wind speeds on this rotation. The timing of arrival has been estimated from empirical techniques due to the lack of persistence data, but recent STEREO-A data suggests it is unlikely to arrive until at least later on Day 2. MOSWOC Enlil is currently bringing the HSS in too early, with this suggesting it should have already arrived.

Geomagnetic activity is expected to be mostly Quiet at first, increasing with the HSS arrival on Day 2 to become Unsettled to Active, with a slight chance of a G1/Minor Storm. Activity then slowly declining through Days 3 and 4 (11-12 Jan).

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 1 | 20 | 5 | 1 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| * | * | * | * | * | * | * |

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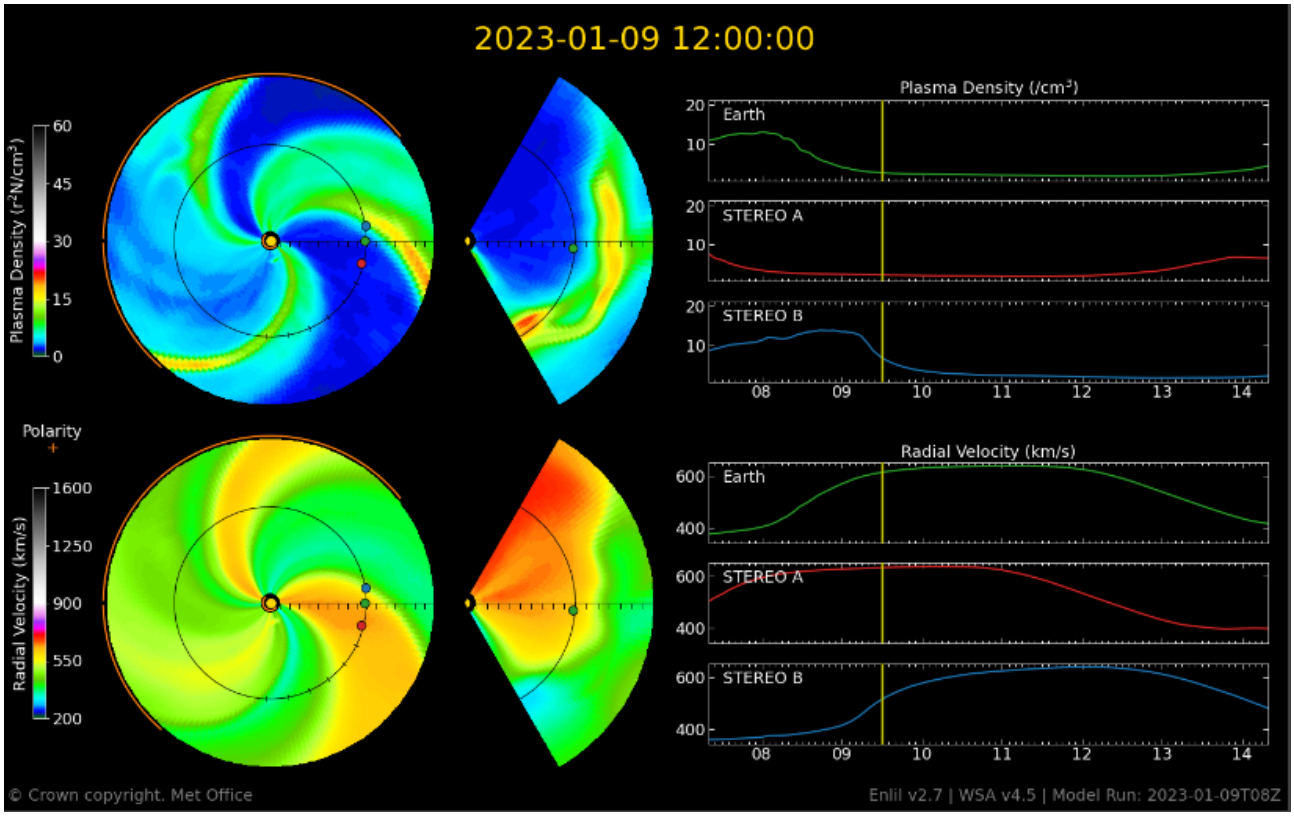
**Figure 2: MOSWOC Enlil showing the HSS arriving too early. It is also expected to be too strong with the wind speeds, with these more likely to be around 500 km/s.**

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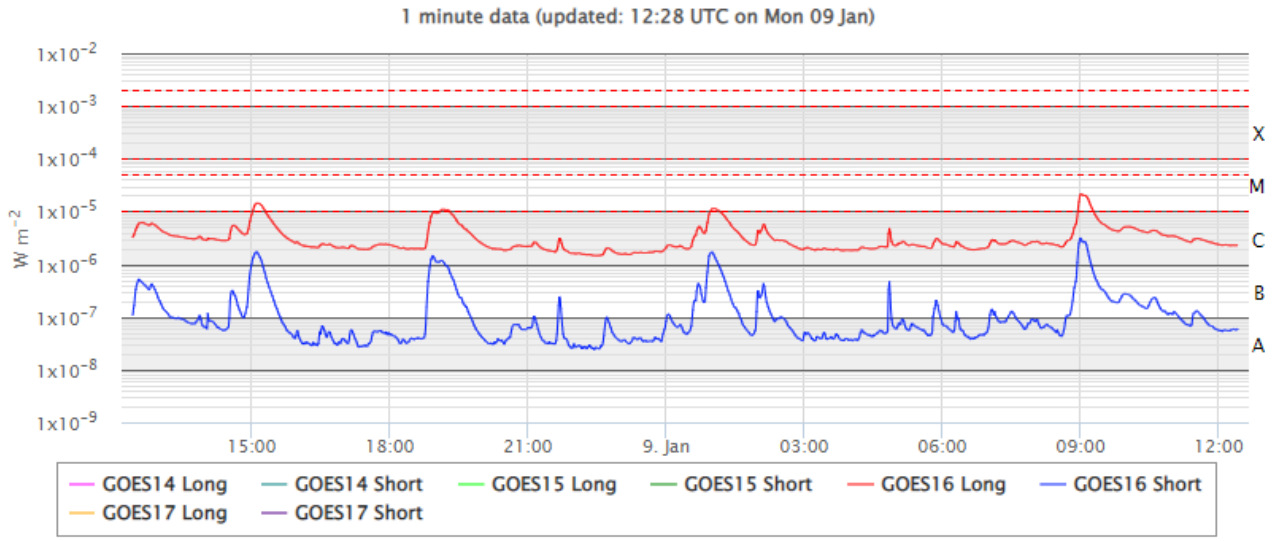
**Radio Blackouts - X-Ray Flares:**
There are currently six sunspot regions on the visible. AR3182 and AR3181 (both Eki/Beta-Gamma-Delta) remains the two largest and most magnetically complex regions on the disc. Both are showing small and weak delta spots. However, AR3184 (currently Hax/Alpha) has been emerging over the southeast limb and has already produced several M-class flares. This region is not yet fully visible and the classification is likely to be more complex than shown here, and it will be re-assessed as it rotates further onto the disc. A new region in the north has emerged in the last 24 hours, but is currently small and simple. The remaining two regions, AR3180 (Hsx/Alpha) and AR3183 (Csi/Beta) are both currently simple and stable.

Solar activity has been Moderate over the past 24 hours, with AR3184 on the SE limb producing most of the recent M-class flares, but the largest M2 flare came from AR3181. Solar activity is likely to be mainly Low to Moderate with a chance of X-class flares. There is the potential for further regions to rotate around the east limb. Far side seismographs are indicating plenty of activity on the far side.

| X Ray Flares<br>Probability | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| Active | R1-R2 M Class | Yes | 70 | 70 | 70 | 70 |
| Very Active | R3 to R5 X Class | No | 25 | 25 | 25 | 25 |

**Figure 3: X-ray flare activity at GOES-16 over the last 24 hours.**

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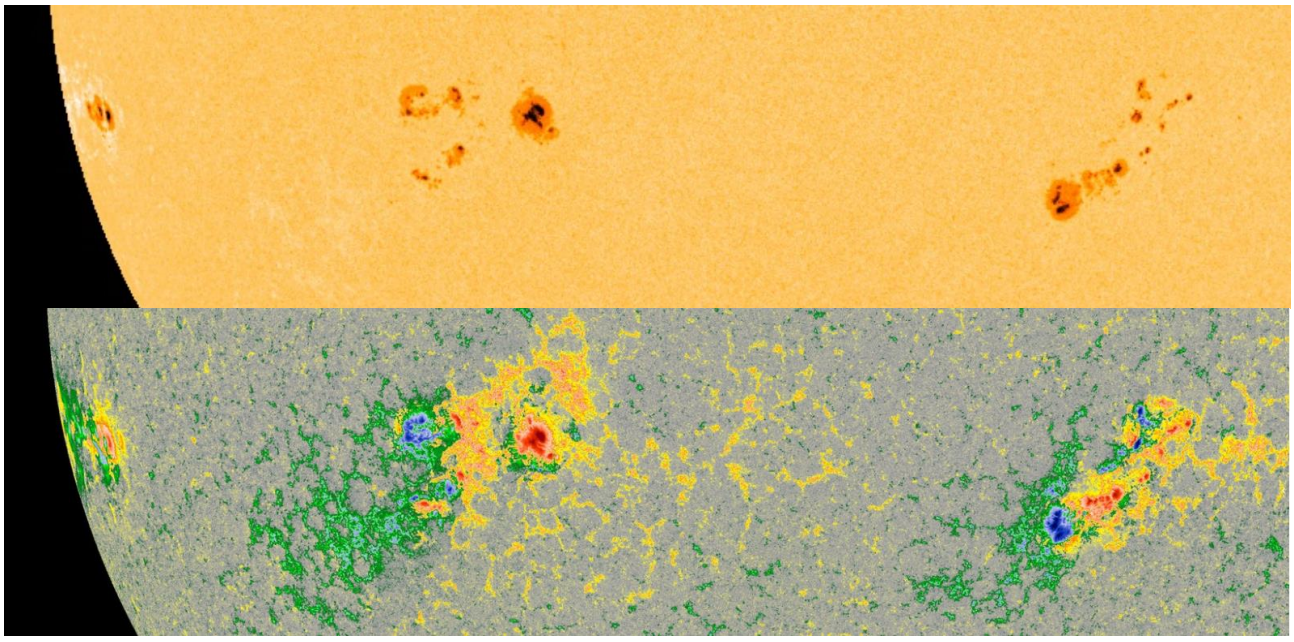
**Solar Radiation Storms - (High Energy Protons):**
The high energy proton flux (greater than 10 MeV) measured by GOES-16 is currently at background levels.

However, any significant flares will bring a risk of proton flux rising, with a slight chance of exceeding the S1/Minor Storm threshold. This is mainly due to the risk presented by both AR3182 and AR3181 as they are now rotating further westwards across the disc, towards a position where they are more likely to connect with Earth for proton storm events. AR3184 will also bear watching in the coming days, depending on how it appears as it rotates fully onto the disc.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 20 | 20 | 20 | 20 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

**Figure 4: SDO intensitygram and magnetogram showing AR3181 (right), AR3182 (middle) and AR3184 (left). All of these regions present a flare risk at the present time, although proton risk is mainly from AR3181 and AR3182 due to their location.**



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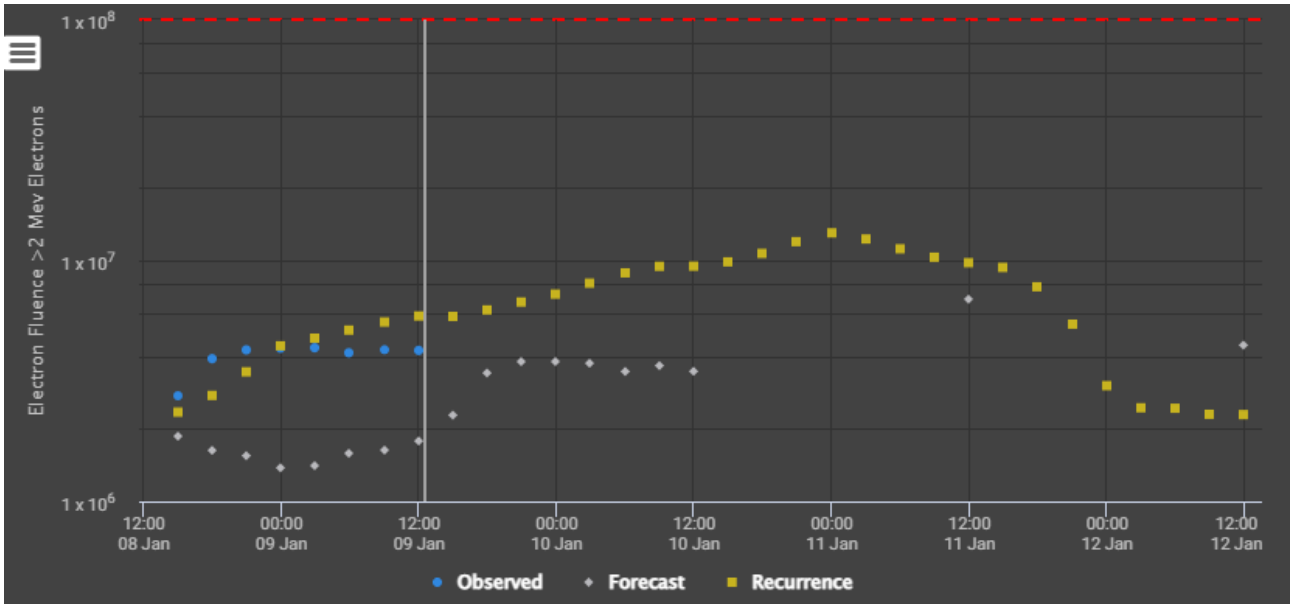
**High Energy Electrons Event (≥ 2MeV):**
High energy electron flux (greater than 2MeV) has been at largely background levels. Electron flux levels may rise a little in the next couple of days, but this is expected to be modest, perhaps reaching Moderate levels at the diurnal peaks. The onset of the next HSS from CH62 either later on Day 1 or more likely during Day 2 (09-10 Jan) is expected to cause a continued suppression of flux levels. This HSS is expected to be stronger than on previous rotation, with any electron response more likely to occur towards the end of this four day period.

Electron fluence is therefore expected to remain below the Active (1e8 integrated pfu) threshold for much of the period, but with a rising trend possible particularly into Day 4 (12 Jan). MOSWOC REFM is forecasting well below Active up to Day 3 (11 Jan), which is currently considered good guidance. Confidence in fluence remaining below Active through most of the period is reasonable, but lower for the likelihood and timing of any increase especially towards the end of the period.

| GEO Electron Environment | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability (Exceedance) | | | (%) | (%) | (%) | (%) |
| Active | ≥ 2 MeV ≥ $1x10^8$ | No | 1 | 5 | 10 | 30 |
| Very Active | ≥ 2 MeV ≥ $1x10^9$ | No | 1 | 1 | 1 | 1 |

**Figure 5: MOSWOC REFM showing a below Active forecast for the next three days. This seems reasonable, although an increase is possible on Day 4.**

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